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**Muto et al.**

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(54) **EYEGROUND IMAGING APPARATUS AND CONTROL METHOD THEREFOR**


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***A61B 3/10*** (2006.01)

(52) **U.S. Cl.**
CPC .................................... ***A61B 3/102*** (2013.01)

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USPC ................. 351/205, 206, 208, 211, 221, 246
See application file for complete search history.



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(57) **ABSTRACT**


A tomographic-image pickup unit is controlled so as to capture a tomographic image in response to a signal input from a signal input unit. Then, a display unit is controlled so as to display the captured. tomographic image. An eyeground-image pickup unit is controlled so as to capture a two-dimensional image in response to a signal input from the signal input unit while the tomographic image. is displayed on the display unit. Therewith, the user can more easily perform imaging, and the time load on the subject is reduced.


**10 Claims, 8 Drawing Sheets**

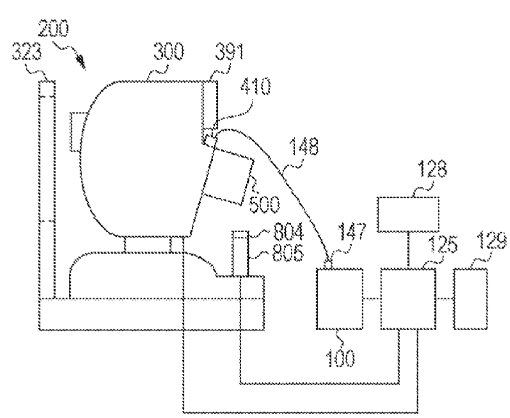

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Fig. 1A

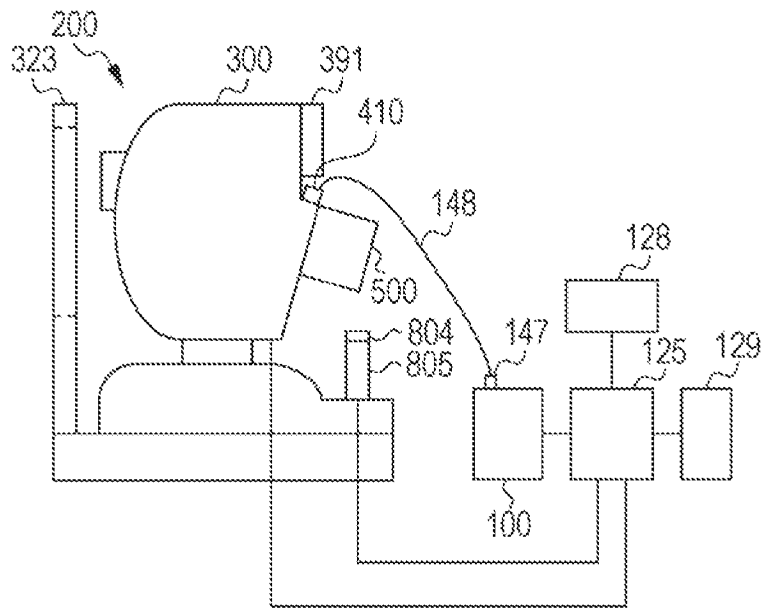
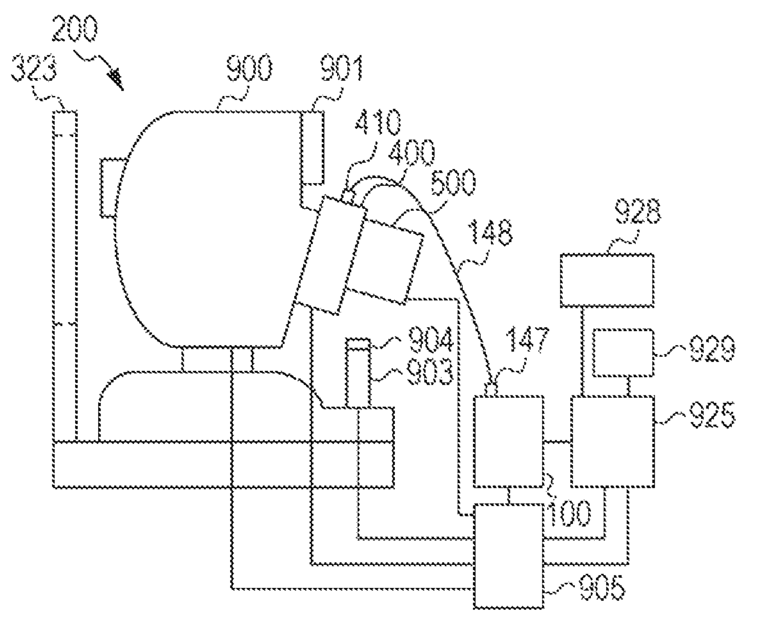

200
323
300
391
410
148
500
128
804
805
147
125
129
100

Fig. 1B


200
323
900
901
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500
148
928
904
903
147
929
925
100
905

Fig. 1C

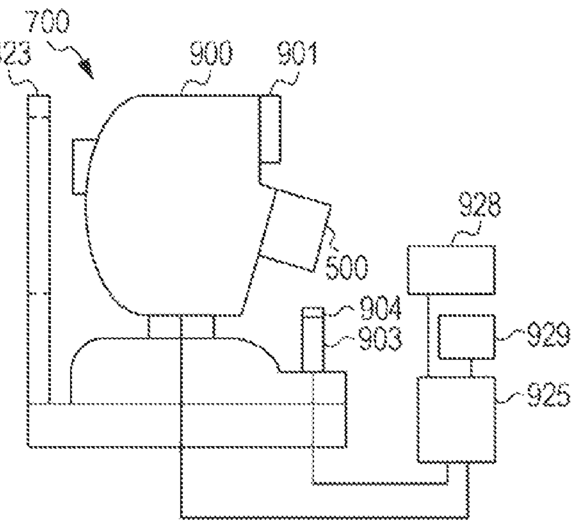

700
323
900
901
500
928
904
903
929
925

Fig. 2A

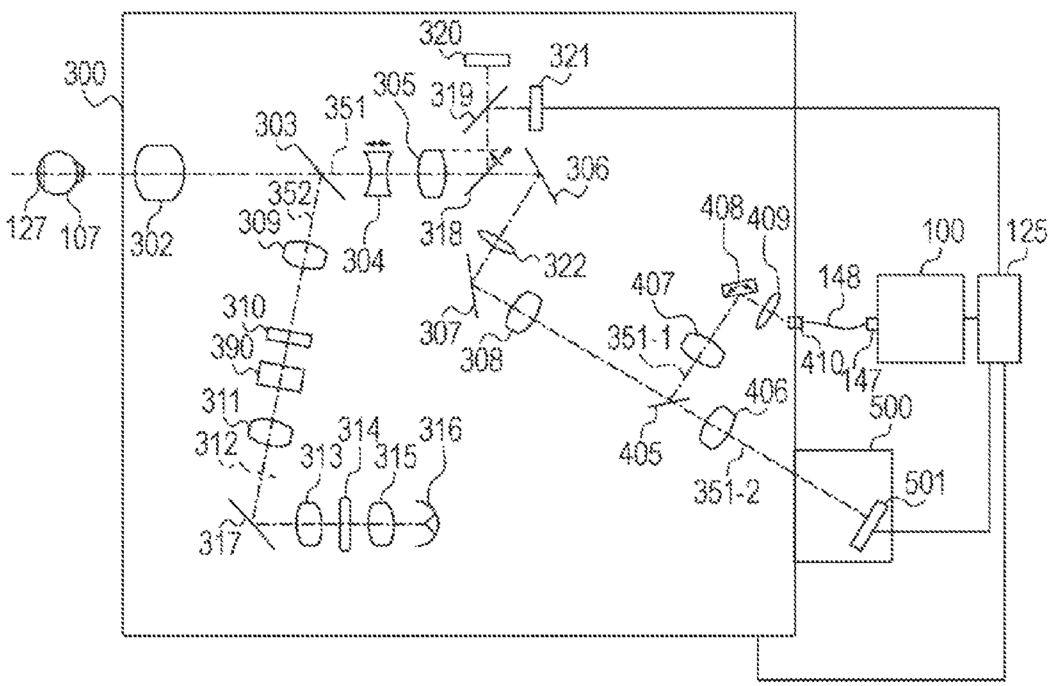

320
321
300
319
305
351
303
306
127
107
302
352
318
304
322
309
408
409
407
100
125
148
310
390
307
308
351-1
410
147
311
406
500
312
313
314
315
316
405
351-2
501
317

Fig. 2B

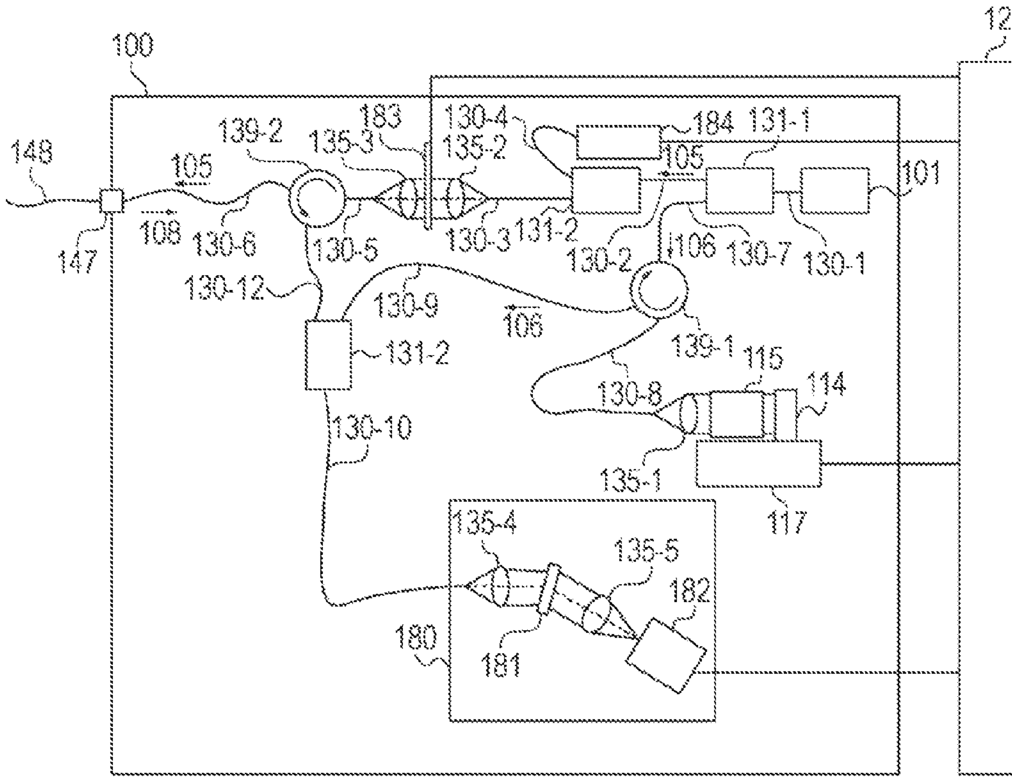

125
100
148
139-2
135-3
183
130-4
135-2
184
131-1
105
105
101
108
130-6
130-5
130-3
131-2
130-2
106
130-7
130-1
147
130-12
130-9
106
139-1
131-2
115
114
130-8
130-10
135-1
117
135-4
135-5
182
180
181

Fig. 3

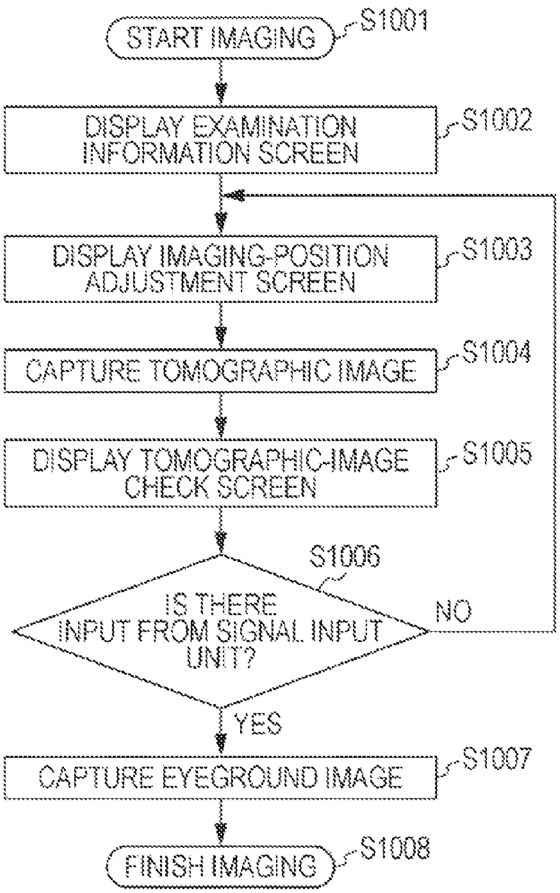

START IMAGING
S1001
DISPLAY EXAMINATION INFORMATION SCREEN
S1002
DISPLAY IMAGING-POSITION ADJUSTMENT SCREEN
S1003
CAPTURE TOMOGRAPHIC IMAGE
S1004
DISPLAY TOMOGRAPHIC-IMAGE CHECK SCREEN
S1005
S1006
IS THERE INPUT FROM SIGNAL INPUT UNIT?
NO
YES
CAPTURE EYEGROUND IMAGE
S1007
FINISH IMAGING
S1008

Fig. 4A

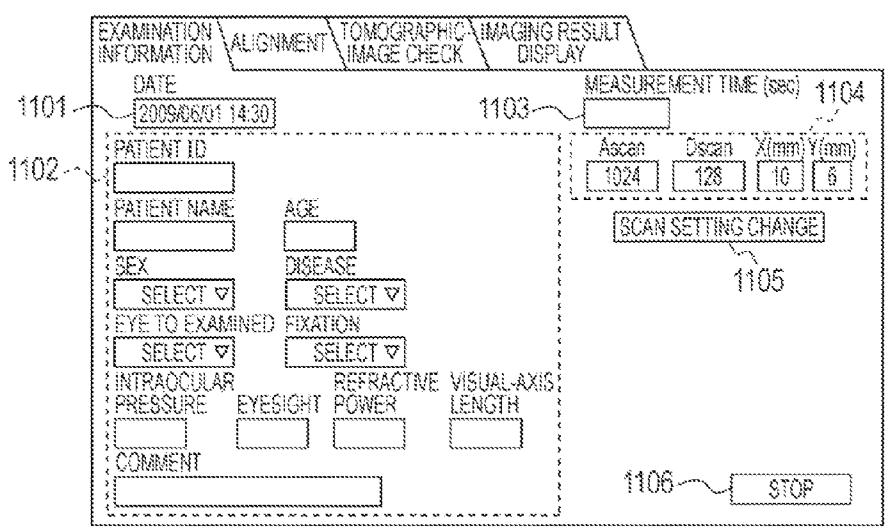

EXAMINATION INFORMATION
ALIGNMENT
TOMOGRAPHIC IMAGE CHECK
IMAGING RESULT DISPLAY
DATE
1101
2009/06/01 14:30
1102
PATIENT ID
PATIENT NAME
AGE
SEX
SELECT
DISEASE
SELECT
EYE TO EXAMINED
SELECT
FIXATION
SELECT
INTRAOCULAR PRESSURE
EYESIGHT
REFRACTIVE POWER
VISUAL-AXIS LENGTH
COMMENT
1103
MEASUREMENT TIME (sec)
1104
Ascan
1024
Bscan
128
X(mm)
10
Y(mm)
6
SCAN SETTING CHANGE
1105
1106
STOP

Fig. 4B

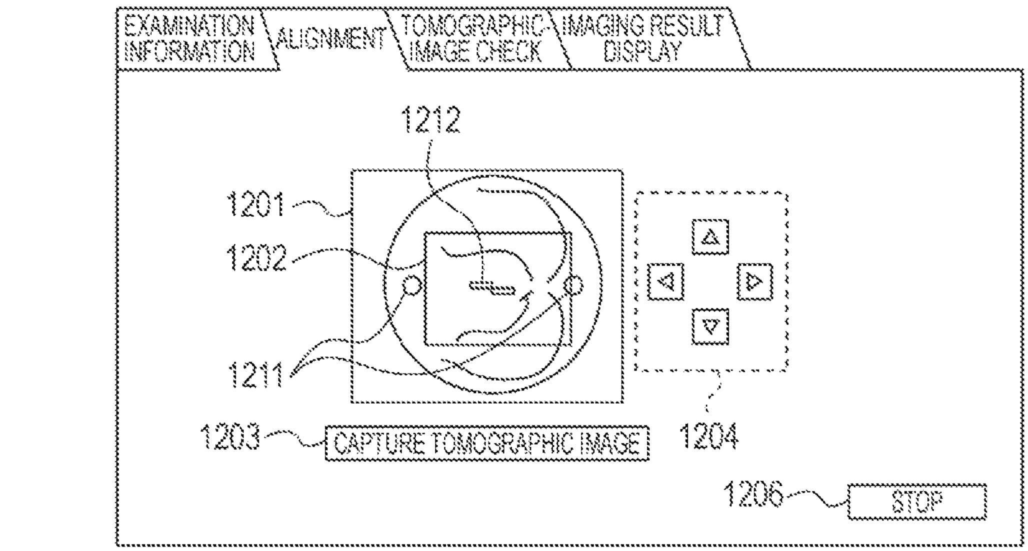

EXAMINATION INFORMATION
ALIGNMENT
TOMOGRAPHIC IMAGE CHECK
IMAGING RESULT DISPLAY
1212
1201
1202
1211
1203
CAPTURE TOMOGRAPHIC IMAGE
1204
1206
STOP

Fig. 4C

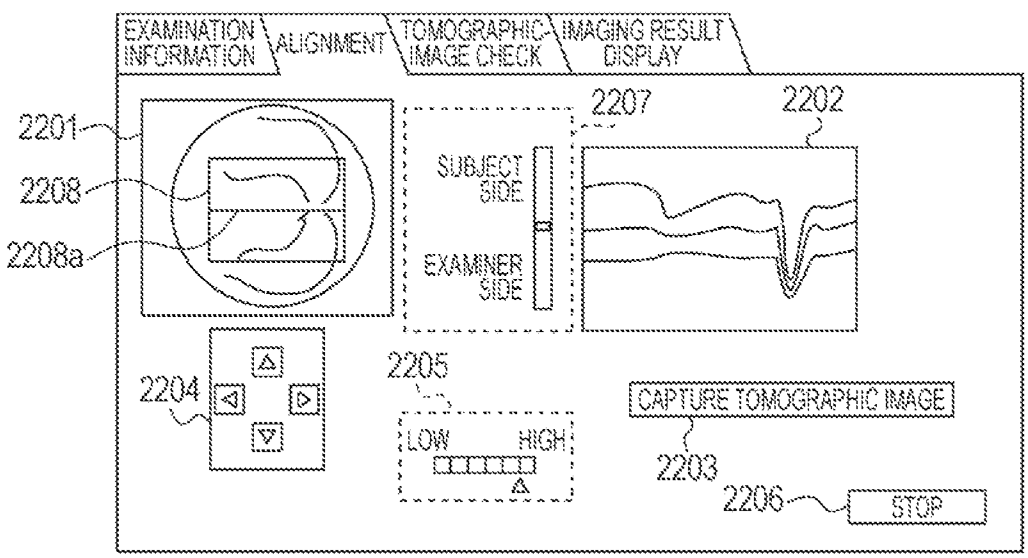

EXAMINATION INFORMATION
ALIGNMENT
TOMOGRAPHIC IMAGE CHECK
IMAGING RESULT DISPLAY
2201
2208
2208a
2207
2202
SUBJECT SIDE
EXAMINER SIDE
2204
2205
LOW
HIGH
CAPTURE TOMOGRAPHIC IMAGE
2203
2206
STOP

Fig. 5A

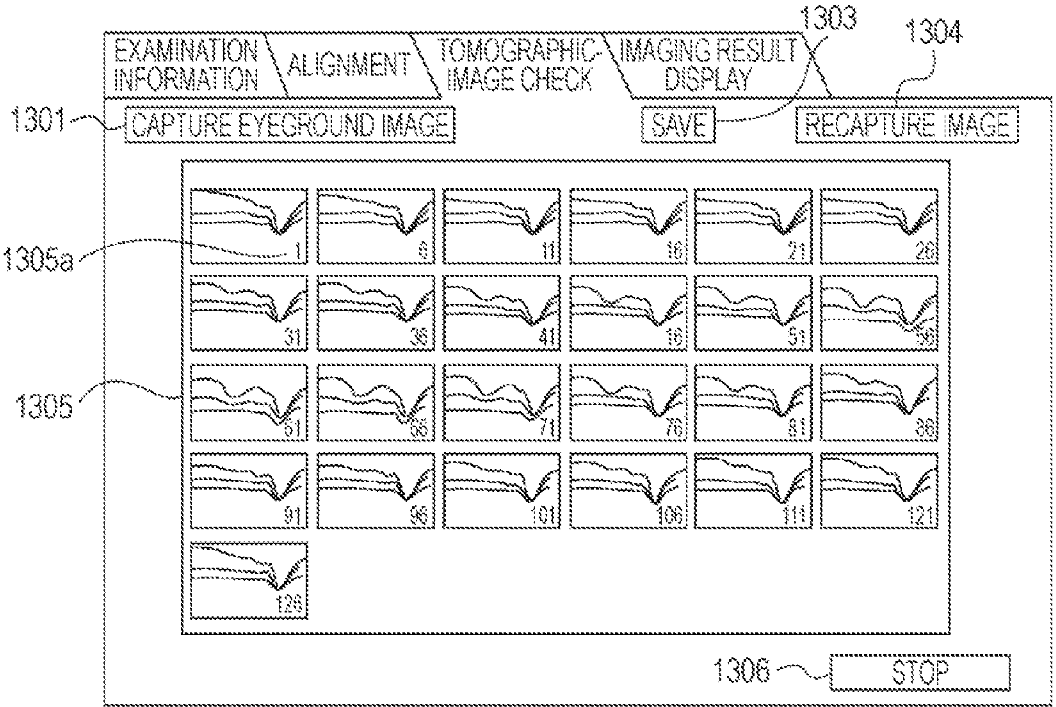

1303
1304
EXAMINATION INFORMATION
ALIGNMENT
TOMOGRAPHIC-IMAGE CHECK
IMAGING RESULT DISPLAY
1301
CAPTURE EYEGROUND IMAGE
SAVE
RECAPTURE IMAGE
1305a
1305
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
121
126
1306
STOP

Fig. 5B

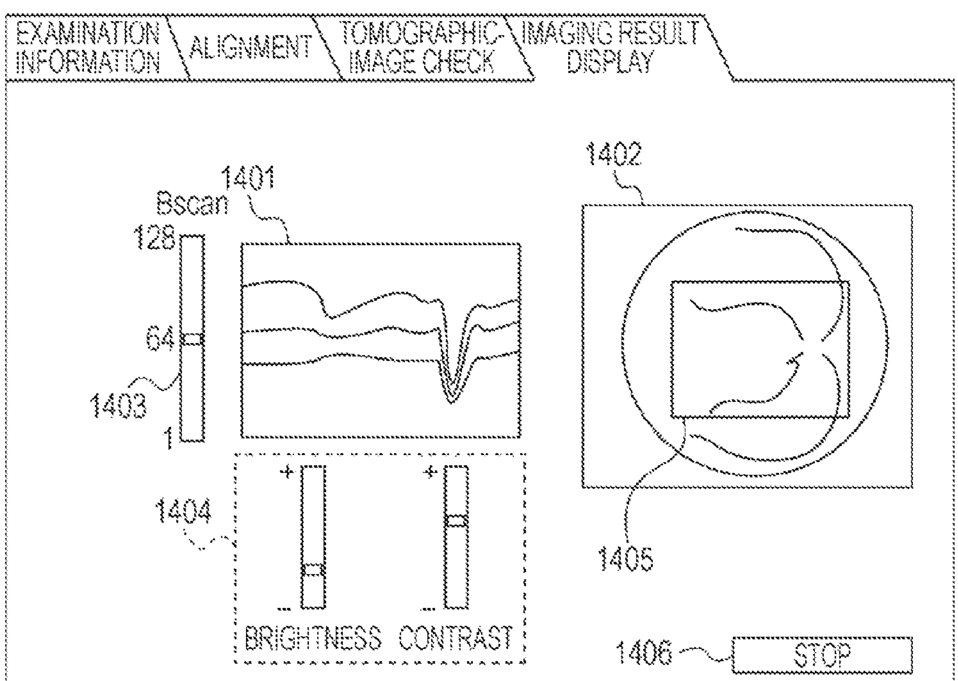

EXAMINATION INFORMATION
ALIGNMENT
TOMOGRAPHIC-IMAGE CHECK
IMAGING RESULT DISPLAY
1401
Bscan
128
64
1403
1
1402
1405
1404
+
-
BRIGHTNESS
CONTRAST
1406
STOP

Fig. 6

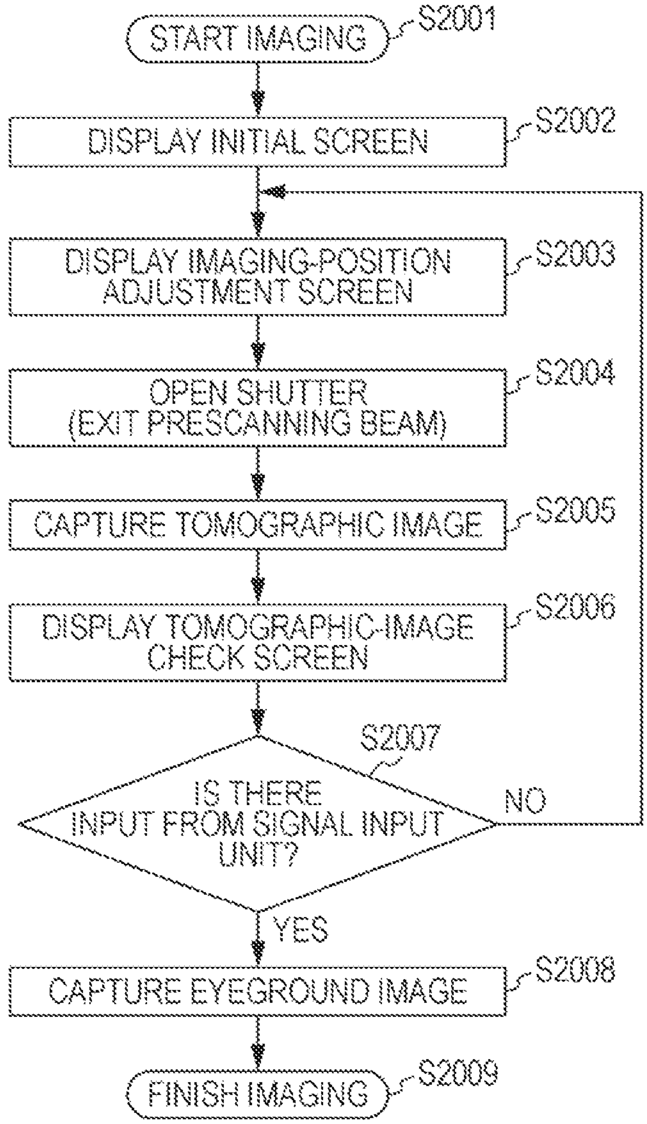
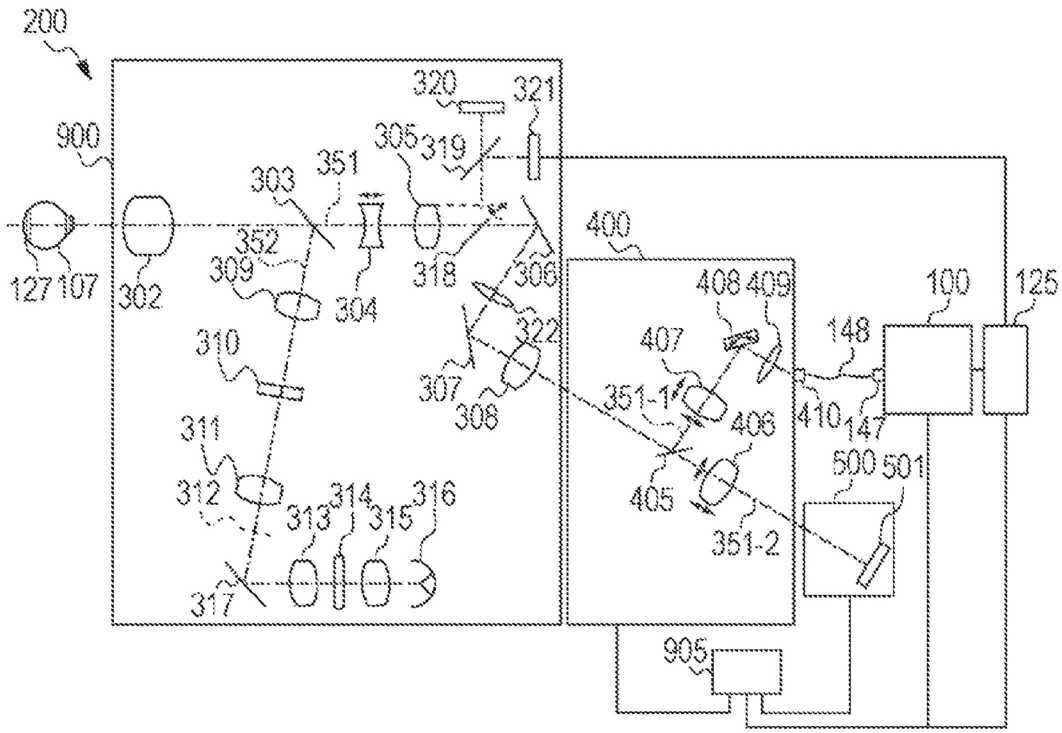

START IMAGING
S2001
DISPLAY INITIAL SCREEN
S2002
DISPLAY IMAGING-POSITION ADJUSTMENT SCREEN
S2003
OPEN SHUTTER (EXIT PRESCANNING BEAM)
S2004
CAPTURE TOMOGRAPHIC IMAGE
S2005
DISPLAY TOMOGRAPHIC-IMAGE CHECK SCREEN
S2006
S2007
IS THERE INPUT FROM SIGNAL INPUT UNIT?
NO
YES
CAPTURE EYEGROUND IMAGE
S2008
FINISH IMAGING
S2009

Fig. 7A


200
900
320
321
305
319
303
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309
302
304
318
306
127
107
400
408
409
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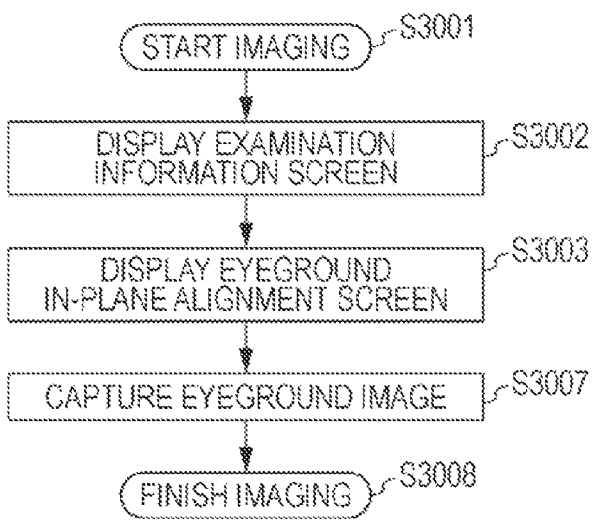
125
148
407
322
310
307
308
351-1
410
147
406
311
500
501
312
313
314
315
316
405
351-2
317
905

Fig. 7B


START IMAGING
S3001
DISPLAY EXAMINATION INFORMATION SCREEN
S3002
DISPLAY EYEGROUND IN-PLANE ALIGNMENT SCREEN
S3003
CAPTURE EYEGROUND IMAGE
S3007
FINISH IMAGING
S3008

# EYEGROUND IMAGING APPARATUS AND CONTROL METHOD THEREFOR

## TECHNICAL FIELD

The present invention relates to an eyeground imaging apparatus and a control method therefor, and more particularly, to an eyeground imaging apparatus used to acquire a surface image and a tomographic image of an eyeground of an eye to he examined, and a control method therefor.

## BACKGROUND ART

In recent years, imaging apparatuses using optical coherence tomography (OCT) that utilizes interference of low coherent light (hereinafter also referred to as OCT apparatuses) have been put into practical use. Since an OCT apparatus can acquire a tomographic image only with a resolution substantially equivalent to the wavelength of light incident on an object to he examined, a tomographic image of a sample can he obtained with a high resolution. Particularly in the ophthalmologic field, the OCT apparatus is useful for obtaining a tomographic image of a retina at the eyeground.

A composite apparatus using an OCT apparatus and a retinal camera (an apparatus for capturing a surface image or a two-dimensional image of the eyeground) in combination is also useful. As such a composite apparatus, Japanese Patent Laid-Open No. 2007-252693 discloses an apparatus capable of simultaneously capturing a surface image and a tomographic image of the eyeground. In this composite apparatus, an OCT apparatus is connected to an optical connector of a retinal camera. When a control button of a joystick provided in the retinal camera is pressed, a surface image and a tomographic image of the eyeground are captured simultaneously.

The time taken to capture multiple tomographic images with the OCT apparatus is longer than the time taken to capture surface images of the eyeground with the retinal camera, and often becomes about several seconds. When a tomographic image is captured with the OCT apparatus, the brightness of an acquired tomographic image is low or the positions of a plurality of tomographic images are misaligned because of a blink or involuntary eye movement (the eye of a subject to be examined randomly and slightly moves against the subject's intention not to move the eye) of the subject. As a result, a desired area that is important in diagnosing the retina and optic disk of the eyeground may not be included in the acquired image. in this case, there is a need to capture a tomographic image of the eyeground of the subject again.

In the apparatus disclosed in Japanese Patent Laid-Open No. 2007-252693, when the control button of the joystick provided in the retinal camera is pressed, a tomographic image is first captured, and a surface image of the eyeground is subsequently captured, Thus, a tomographic image and a surface image are captured in succession in this order by one press of the control button. In this case, the surface image of the eyeground is captured before the operator checks the tomographic image.

In contrast, to obtain an image of the eyeground with the retinal camera, it is necessary to illuminate the eyeground with a flare of flashlight. Since the quantity of illumination light is large, the pupil of the subject contracts after a surface image of the eyeground is captured. In this case, according to the subject, it takes several minutes until the pupil dilates. For this reason, the next tomographic image can be captured only when several minutes pass after the surface image of the eyeground is captured,



For the above-described reason, the user of the apparatus needs to wait for a long period to capture a tomographic image again after a surface image of the eyeground is captured, and this reduces usability. Moreover, the subject whose eyeground is to be imaged has a heavy time load.

## CITATION LIST

### Patent Literature

PTL 1: Japanese Patent Laid-Open No. 2007-252693

## SUMMARY OF INVENTION

An eyeground imaging apparatus according to an aspect of the present invention includes an eyeground-image pickup unit configured to capture a two-dimensional image of a surface of an eyeground of a subject; a tomographic-image pickup unit configured to capture a tomographic image of the eyeground, the tomographic-image pickup unit having an optical system common to the eyeground-image pickup unit; an output unit configured to output a signal relating to the tomographic image so as to display the tomographic image on a display unit; a control unit configured to exert control over the eyeground-image pickup unit, the tomographic-image pickup unit, and the output unit; and a signal input unit configured to input a signal relating to the control to the control unit, The control unit controls the tomographic-image pickup unit so as to capture the tomographic image in response to a signal input from the signal input unit, controls the output unit so as to output the signal relating to the captured tomographic image to the display unit, and controls the eyeground-image pickup unit so as to capture the two-dimensional image in response to a signal input from the signal input unit when the signal relating to the tomographic image is output from the output. unit.

An imaging method for an eyeground imaging apparatus according to another aspect of the present invention includes the steps of capturing tomographic image of an eyeground of a subject; outputting a signal relating to the tomographic image so as to display the tomographic image on a display unit; selecting an operation of capturing a two-dimensional image of a surface of the eyeground or an operation of retaking a tomographic image when the signal relating to the tomographic image is output; and carrying out the selected. operation.

An eyeground imaging apparatus according to a further aspect of the present invention includes an eyeground-image pickup unit configured to capture a two-dimensional image of a surface of an eyeground of a subject; a tomographic-image pickup unit configured to capture a tomographic image of the eyeground, the tomographic-image pickup unit having an optical system common to the eyeground-image pickup unit; an output unit configured to output a signal relating to screen information to be displayed on a display unit; a control unit configured to control the eyeground-image pickup unit, the tomographic-image pickup unit, and the output unit; and a signal input unit configured to input a signal to the control unit. The control unit controls the output unit so as to output a signal for displaying the screen information on the display unit, and exerts control so that one of the eyeground-image pickup unit and the tomographic-image pickup unit operates, on the basis of a kind of the screen information output from the output unit in response to the signal input from the signal input unit.

The screen information may include an adjustment screen for adjusting the two-dimensional image and the tomographic image, The control unit may control the eyeground-image pickup unit when the screen information for displaying the tomographic image is output from the output unit and a signal is input from the signal input unit.

The control unit may control the tomographic-image pickup unit when the screen information for displaying the adjustment image is output from the output unit and a signal is input from the signal input unit.

A control method according to a further aspect of the present invention is provided for an eyeground imaging apparatus including ah eyeground-image pickup unit configured to capture a two-dimensional image of a surface of an eyeground of a subject, a tomographic-image pickup unit configured to capture a tomographic image of the eyeground, the tomographic-image pickup unit having an optical system common to the eyeground-image pickup unit, an output unit configured to output a signal relating to screen information to be displayed on a display unit, a control unit configured to control the eyeground-image pickup unit, the tomographic-image pickup unit, and the output unit, and a signal input unit configured to input a signal to the control unit. The control method comprises the steps of controlling the output unit so as to output a signal for displaying the screen information on the display unit; and exerting control so hat a pickup operation is performed by one of the tomographic-image pickup unit and the eyeground-image pickup unit, on the basis of a kind of the screen information output from the output unit in response to the signal input from the signal input unit.

A control method according to a still further aspect of the present invention is provided for an eyeground imaging apparatus including an eyeground-image pickup unit configured to capture a two-dimensional image of a surface of an eyeground of a subject, a tomographic-image pickup unit configured to capture a tomographic image of the eyeground, the tomographic-image pickup unit having an optical system common to the eyeground-image pickup unit, an output unit configured to output a signal for displaying the tomographic image to a display unit, a control unit configured to control the eyeground-image pickup unit, the tomographic-image pickup unit, and the output unit, and a signal input unit configured to input a signal to the control unit. The control method comprises the steps of controlling the tomographic-image pickup unit so as to capture the tomographic image in response to the signal input from the signal input unit; controlling the output unit so as to output the signal for displaying the captured tomographic image on the display unit; and controlling the eyeground-image pickup unit so as to capture the two-dimensional image when the signal for displaying the tomographic image is output from the output unit and a signal is input from the input unit.

According to the present invention, a surface image of the eyeground can be captured after a tomographic image is checked. Hence, even if there is a need to capture a tomographic image again because of image displacement due to, for example, involuntary eye movement, the tomographic image can be efficiently captured by checking the previous tomographic image. Moreover, the user can more easily capture the image, and the time load on the subject is reduced.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A is a schematic view illustrating an overall configuration of an eyeground imaging apparatus according to firs (and second examples,

FIG. **1**B is a schematic view illustrating an overall configuration of an eyeground imaging apparatus according to a third example.

FIG. **1**C is a schematic view illustrating the overall configuration of the eyeground imaging apparatus according to the third example.

FIG. **2**A is a schematic view illustrating a configuration of an optical system of the first example.

FIG. **2**B is a schematic view illustrating the configuration of the optical system of the first example.

FIG. **3** is a flowchart showing image acquisition in the first example.

FIG. **4**A illustrates a display screen of the first and second examples.

FIG. **4**B illustrates a display screen of the first and second examples.

FIG. **4**C illustrates a display screen of the first and second examples.

FIG. **5**A illustrates a display screen of the first example.

FIG. **5**B illustrates a display screen of the first example.

FIG. **6** is a flowchart showing image acquisition in the second example.

FIG. **7**A is a schematic view illustrating a configuration of an optical system of the third example.

FIG. **7**B is a flowchart showing image acquisition in the third example.

## DESCRIPTION OF EMBODIMENTS

An eyeground imaging apparatus according to an embodiment will be described with reference to FIG. **1**A and so on. An eyeground apparatus refers to an apparatus that can capture an image to be used for observation of the eyeground of a subject to be examined. In this case, observation may include observation with the naked eye.

An eyeground imaging apparatus **200** of the embodiment includes an eyeground-image pickup unit (also referred to as a retinal-camera main unit) **300** that can capture a two-dimensional surface image of an eyeground (e.g., an eyeground image **1402** shown in FIG. **5**B). Preferably, a camera unit **500** is removably attached to the eyeground-image pickup unit **300**.

A tomographic-image pickup unit **100** has an optical system common to the eyeground-image pickup unit **300**, and serves to capture a tomographic image of the eyeground (e.g., a B-scan image **1401** shown in FIG. **5**B). Preferably, the tomographic-image pickup unit **100** and the eyeground-image pickup unit **300** are optically connected by an optical fiber **148**.

A display unit **128** for displaying the tomographic image **1401** is connected via an output unit of the apparatus. The output unit outputs a signal relating to the tomographic image **1401** to the display unit **128**, and may be incorporated in a control unit **125** that will be described below or be provided separately from the control unit **125**.

The control unit **125** controls the eyeground-image pickup unit **300**, the tomographic-image pickup unit **100**, and the output unit.

Signals for controlling the eyeground-image pickup unit **300**, the tomographic-image pickup unit **100**, and the output unit are input to a signal input unit **804**. The signal input unit **804** is not limited to a control switch **804** provided in a joystick **805** shown in FIG. **1**A, but may be any member capable of inputting signals to the control unit **125**, for example, a tomographic-image pickup button **1203** shown in FIG. **4**B, In this case, the control unit **125** performs the following steps (a) to (c):

(a) In response to a signal input from the signal input unit **804** (e.g., a first signal input by the first press of the control switch **804**), the control unit **125** controls the tomographic-image pickup unit **100** so as to capture a tomographic image (e.g., a check tomographic image **1305** including a plurality of B-scan images shown in FIG. **5**A).

(b) The control unit **125** controls the output unit so as to output a signal relating to the captured tomographic image **1305**.

(c) When the signal relating to the tomographic image **1305** is output the output unit, in response to a signal input from the signal input unit **804** (e.g., a second signal input by the second press of the control switch **804**), the control unit **125** controls the eyeground-image pickup unit **300** so as to capture a two-dimensional image **1402**,

The above steps allow the eyeground image **1402** to be captured after the tomographic image **1305** is checked. Even when there is a need to capture a tomographic image again because of image misalignment due to involuntary eye movement, the tomographic image can be efficiently captured by checking the previous tomographic image.

It is preferable to provide a selection input unit **1304** (also referred to as a tomographic-image retake button) for selecting retake of a tomographic image **1305**. The selection input unit **1304** may be formed by any unit capable of inputting a signal to the control unit **125**, for example, an alignment tab. Preferably, when a signal relating to a tomographic image **1305** is output from the output unit, the control unit **125** controls the tomographic-image pickup unit **100** so as to capture a tomographic image (retake a check tomographic image **1305**) in response to a signal input from the selection input unit **1304**. In this case, a tomographic image can be retaken before the pupil of the subject dilates, and therefore, retake can be repeated in a short time.

Preferably, the control unit **125** outputs a signal relating to screen information (e.g., screens shown in FIGS. **4** and **5**) from the output unit to the display unit **128** on the basis of a signal input from the signal input unit **804** or the selection input unit **1304**.

Preferably, the above-described screen information includes an adjustment screen (e.g., screens to be displayed by clicking an alignment tab, as shown in FIGS. **4**B and **4**C) for adjusting an imaging mode in which a two-dimensional image **1402** or a tomographic image **1401** is captured (e.g., various parameters for imaging, position adjustment). In this case, preferably, the control unit **125** controls the eyeground-image pickup unit **300** or the tomographic-image pickup unit **100** on the basis of a signal relating to the imaging mode adjusted on the adjustment screen.

The first signal in the above-described step (a) may be input by the second press of the control switch **804**. In this case, a signal input by the first press is a signal for capturing a tomographic image for a preview, and a signal input by the second press after the preview serves as the first signal. Further, the second signal is a signal input by the third press. These signals will be described in detail in the following description of a second example.

It is also preferable to provide an adaptor unit **400**, as shown in FIG. **1**B. In this case, the eyeground-image pickup unit **300** includes a main unit **900** and a camera unit **500** in which a camera is detachably mounted. The adaptor unit **400** is removably provided between the main unit **900** and the camera unit **500**, and splits the optical path toward the camera unit **500** and the tomographic-image pickup unit **100**. In this case, it is preferable to provide a control circuit unit **905** for inputting a signal input from a signal input unit **904** to the adaptor unit **400** and the main unit **900**. These units will be described in detail in the following description of a third example.

While the eyeground imaging apparatus according to the embodiment has been described above, the present invention is not limited to the embodiment.

Control Method

Next, a description will be given of a control method for the eyeground imaging apparatus of the embodiment. The control method includes the following steps (a-1) and (b-1):

(a-1) a step of controlling the output unit so as to output a signal for displaying screen information (e.g., screens shown in FIGS. **4** and **5**) to the display unit; and

(b-1) a step of exerting control so that one of the tomographic-image pickup unit **100** and the eyeground-image pickup unit **300** performs imaging according to the kind of the screen information output from the output unit (e.g., screens shown in FIGS. **4**B and **4**C to be displayed by a click of an alignment tab, the screen to be displayed differs according to the tab).

Imaging Method

A description will be given of an imaging method adopted in the eyeground imaging apparatus of the embodiment. The imaging method includes the following steps (a-2) to (d-2):

(a-2) a step of capturing a tomographic image of the eyeground of a subject;

(b-2) a step of outputting a signal relating to the tomographic image so as to display the tomographic image on the display unit; (c-2) a step of capturing a two-dimensional surface image of the eyeground (e.g., clicking an eyeground-image pickup button **1301** shown in FIG. **5**A) or retaking a tomographic image (e.g., clicking a tomographic-image retake button **1304** shown in FIG. **5**A) when the signal relating to the tomographic image is output; and

(d-2) a step of carrying out the selected image pickup operation.

Therewith, the surface image of the eyeground can be captured after the tomographic image is checked. For this reason, even if there is a need to retake a tomographic image because of image misalignment due to involuntary eye movement, the tomographic image can be efficiently captured by checking the previous tomographic image.

Storage Medium and Program

As another embodiment, the imaging method of the above-described embodiment may be stored, as a program to be executed by a computer, in a computer-readable storage medium (e.g., a flexible disk, a hard disk, an optical disc, a magnetooptical disc, a CD-ROM, a CD-R, a magnetic tape, a nonvolatile memory card, a ROM, an EEPROM, or a Blu-ray disc).

Examples_First Example: Eyeground Imaging Apparatus and Control Method therefor

First, an overall configuration of an eyeground imaging apparatus according to a first example will be described with reference to FIG. 1A. FIG. **1**A is aside view of an eyeground imaging apparatus **200** of the first example. The eyeground imaging apparatus **200** includes a tomographic-image pickup unit **100**, a retinal-camera main unit **300**, and a camera unit **500**. The main unit **300** is optically connected to the camera unit **500**, and is also optically connected to the tomographic-image pickup unit **100** by an optical fiber **148**, The main unit **300** and the tomographic-image pickup unit **100** have a connector **410** and a connector **147**, respectively. A jaw rest **323** fixes the jaw and forehead of the subject so as to fix the eye to be examined. A monitor **391** displays, for example, an infrared image for adjustment during image pickup operation.

A joystick **805** controls movement for aligning the main unit **300** with the eye to be examined, and a control switch **804** serves as a signal input unit for inputting signals for capturing a tomographic image and an eyeground image. A control unit **125** is formed by a personal computer, and controls the main unit **300** and the camera unit **500** and controls the layout of tomographic images and displays of tomographic images and eyeground images. A control-unit monitor **128** serves as a display unit, and a storage unit **129** is formed by a hard disk that stores programs and obtained images. The storage unit **129** may be incorporated in the control unit **125**. Here, the camera unit **500** is a general digital single-lens reflex camera, and is connected to the main unit **300** by a general camera mount.

Configuration of Optical System in Main Unit

A configuration of an optical system in the main unit **300** will be described with reference to FIG. **2**A.

The eyeground imaging apparatus **200** obtains a tomographic image (OCT image) and an eyeground image (planar image) of a retina **127** of an eye **107** to be examined with the tomographic-image pickup unit **100** and the camera unit **500**.

First, the main unit **300** will be described. An objective lens **302** is provided to oppose the eye **107**, and the optical path is split into an optical path **351** and an optical path **352** by a perforated mirror **303**.

The optical path **352** forms an illumination optical system for illuminating the eyeground of the eye **107**. In a lower part of the eyeground-image pickup unit **300**, a condenser lens **313**, a stroboscopic tube **314** used to image the eyeground of the eye **107**, a condenser lens **315**, a halogen lamp **316** used to position the eye **107**, and a mirror **317** are provided. Illumination light (raveling from the halogen lamp **316** via the stroboscopic tube **314** is shaped into a ring-shaped light beam by a ring slit **312**, travels via a lens **311**, an alignment optical system **390**, an optical filter **310**, and a lens **309**, is reflected by the perforated mirror **303**, and then illuminates the eyeground of the eye **107**. The alignment optical system **390** projects a split image used for focusing on the eyeground and an index used to align the eye **107** with the optical axis of the optical system of the main unit **300**.

The optical path **351** forms an imaging optical system for capturing a tomographic image and an eyeground image of the eyeground of the eye **107**, On the right side of the perforated mirror **303**, a focus lens **304** and an imaging lens **305** are provided. Here, the focus lens **304** is supported to be movable in the optical-axis direction with operation of a knob (not shown) by the examiner. The optical path **351** is further guided to a fixation lamp **320** and an infrared area sensor **321** via a quick-return mirror **318**. The quick-return mirror **318** transmits infrared light within a wavelength range used to capture a tomographic image, but does not transmit visible light used to capture an eyeground image. Image information acquired by the infrared area sensor **321** is displayed on the display unit: **128** or the monitor **391** (see FIG. **1**), and is used to position the eye **107**. Here, a surface of the quick-return mirror **318** is covered with a silver film and a protective film that are deposited in order. A dichroic mirror **319** is designed to separately guide the visible light toward the fixation lamp **320** and the infrared light toward the infrared area sensor **321**. Further, the optical path **351** is guided to the camera unit **500** via a mirror **306**, a field lens **322**, a mirror **307**, and a relay lens **308**.

On the other hand, the optical path **351** is split into an optical path **351-1** for pickup of a (omographic image and an optical path **351-2** for pickup of an eyeground image. Here, a relay lens **406** is provided in the optical path **351-2**, and a relay lens **407**, an XY scanner **408**, and a collimating lens **409** are provided in the optical path **351-1**. While the XY scanner **408** is shown by one mirror for simplicity, it is, in actuality, formed by adjacent two mirrors, namely, an X-scan minor and a Y-scan mirror, and performs raster-scanning over the retina **127** in a direction perpendicular to the optical axis. The optical axis of the optical path **351-2** is adjusted in a manner such as to coincide with the rotation centers of the two mirrors in the XY scanner **408**. The optical fiber **148** is attached by the connector **410**.

The camera unit **500** is a digital single-lens reflex camera for capturing an eyeground image, Since the camera unit **500** is connected to the main unit **300** by a general camera mount, it is easy to attach and detach. An eyeground image is formed on a surface of an area sensor **501**.

Configuration of Tomographic-Image Pickup Unit

Next, a configuration of the tomographic-image pickup unit **100** will be described with reference to FIG. **2**B.

In the first example, the tomographic-image pickup unit **100** obtains a tomographic image of the retina **127** of the eye **107**. Further, since a part of the optical system of the tomographic-image pickup unit **100** is formed by an optical fiber, size reduction is achieved. While the optical fiber is adopted in the optical path in the first example, it does not always need to be used.

With reference to FIG. **2**B, the configuration of the tomographic-image pickup unit **100** will be described. The tomographic-image pickup unit **100** forms a Mach-Zehnder interferometer. Light emitted from a light source **101** is split into measurement light **105** and reference light **106** via an optical coupler **131-1**. Further, light traveling toward a light detector **184**, such as a photodetector, for monitoring the light quantity branches off from the measurement light **105** via an optical coupler **131-2**, The measurement light **105** is guided to an optical fiber **130-5** via lenses **135-2** and **135-3**. A shutter **183** is provided between the lenses **135-2** and **135-3**, and the control unit **125** can determine whether or not to block the light traveling toward the eye **107** with the shutter **183**. More specifically, a solenoid (not shown) of the shutter **183** is controlled by the control unit **125** so that a plate-shaped light block member moves into and out of the optical path. Since the measurement light **105** is guided by an optical circulator **139-2** in a direction of arrow shown in the optical circulator **139-2**, it is guided by an optical fiber **130-6**, and travels toward the main unit **300** via the connector **147**,

After that, the measurement light **105** is applied onto the retina **127** of the eye **107** to be examined via the main unit **300**, is returned as return light **108** by reflection and scattering of the retina **127**. The return light **108** is directed by the optical circulator **139-2** in the direction of the arrow in the optical circulator **139-2**, is guided to an optical fiber **130-12**, and then reaches an optical coupler **131-2**.

In contrast, the reference light **106** travels via an optical circulator **139-1** in a direction of arrow shown in the optical circulator **139-1**. Hence, the reference light **106** is guided to an optical fiber **130-8**, reaches a mirror **114** via a lens **135-1** and a dispersion-compensating glass **115** inserted to align dispersions of the measurement light and the reference light, and is then reflected by a mirror **114**. The reference light **106** reaches the optical circulator **139-1** via the dispersion-compensating glass **115**, the lens **135-1**, and the optical fiber **130-8**, and travels in the direction of the arrow shown in the optical circulator **139-1**. Thus, the reference light **106** reaches the optical coupler **131-2** along an optical fiber **130-9**.

The optical coupler **131-2** multiplexes the return light **108** and the reference light **106**. in the interferometer, when the optical path lengths of the measurement light and the reference light become substantially equal, interference occurs.

Accordingly, the minor **114** is held to be adjustable. After the reference light **106** and the return light **108** are multiplexed, they are guided to a spectroscope **180**. in the spectroscope **180**, the multiplexed light is collimated by a lens **135-4**, is demultiplexed by a diffraction grating **180**, and is focused onto a line sensor **182** by a lens **135-5**.

Next, the surroundings of the light source **101** will be described. The light source **101** is formed by a super luminescent diode (SLD) serving as a typical low coherent light source, and has a wavelength of 830 nm and a bandwidth of 50 nm. The bandwidth is an important parameter because it has an influence on resolution of an obtained tomographic image in the optical-axis direction. While the SLD is selected as the light source in this example, any light source capable of emitting low coherent light, such as an amplified spontaneous emission (ASE) light source, may be used. In consideration of measurement of the eye, near-infrared light is suitably adopted. Further, it is preferable that the wavelength be as short as possible because the wavelength has an influence on resolution of an obtained tomographic image in the lateral direction, and accordingly, the wavelength is set at 830 nm in the first example. Other wavelengths may be selected according to the portion of the object to be measured. Light emitted from the light source **101** is guided to the optical coupler **131-1** through the optical fiber **130-1**.

While the Mach-Zehnder interferometer is used as the interferometer in the first example, it may be replaced with a Michelson interferometer having a simpler structure. In general, it is preferable to use a Mach-Zehnder interferometer when the light quantity difference between the measurement light and the reference light is large, and to use a Michelson interferometer when the light quantity difference is relatively small.

For example, the shutter **183** may be formed of liquid crystal that can control transmission and block of the light, or may be formed by a mirror whose angle is controllable so as to permit or inhibit entry of light into the optical fiber **130-5**.

Method for Capturing Tomographic Image and Eyegrouud Image **1**

Next, a description will be given of a method for capturing a tomographic image and an eyeground image with the eyeground imaging apparatus **200**. The eyeground imaging apparatus **200** can obtain a tomographic image of a desired portion of the retina **127** by controlling the XY scanner **408**, and obtains en eyeground image after the tomographic image is obtained. The following steps shown in an imaging flowchart of FIG. **3** will he described in order.

In Step S**1001**, imaging is started. The control unit **125** executes an imaging program, and displays an imaging screen on the control-unit monitor **128**.

In Step S**1002**, an examination information screen (or initial screen) is displayed on the control-unit monitor **128**. This display is performed immediately after the imaging screen is displayed. FIG. **4**A illustrates the examination information screen.

The date and time are displayed in a portion **1101**. Patient information is entered in a portion **1102**. A patient ID, patient name, age, intraocular pressure, eyesight, refractive power, and visual axis length can be entered in characters or numerals from an input device (not shown) such as a keyboard. Further, the sex, disease, eye to be examined (left or right), and fixation position (macula, optic disk) can each be selected from a pull-down. menu. Since broken lines are shown in FIG. **4**A in order to describe the first example, they do not need to be displayed actually.

In a portion **1104**, scan settings of the XY scanner **408** for capturing a tomographic image are displayed. The number of image pickup operations to be performed in the x-direction (a direction substantially perpendicular to the depth direction of the eyeground of the subject) is displayed in "Ascan" (a tomographic image to be captured in one pickup operation in the depth direction). Further, the number of image pickup operations to be performed in the y-direction (a direction substantially perpendicular to the depth direction and substantially perpendicular to the x-direction) is displayed in "Bscan" (a two-dimensional tomographic image). Moreover, image pickup areas in the x-direction and y-direction are shown in units of mm.

Scanning of the XY scanner **408** will now be described. First, scanning is performed in the x-direction, and the image pickup area in the x-direction is read a number of times equal to the Ascan number with the line sensor **182**. After that, the scanning position in the y-direction is moved, and scanning in the x-direction is performed again. These operations are repeated by scanning the y-direction imaging area a number of times equal to the Bscan number. A portion **1103** indicates an estimated time to be taken for scanning determined by the displayed scan settings. For example, when the reading frequency of the line sensor **182** is 35 kHz, the measurement time displayed in the portion **1103** is given as follows:

Math 1

$$(1/35000)\times 1024\times 128\approx 3.74\text{ sec}$$

To change the displayed scan settings, a scan-setting change button **1105** is clicked to display a special setting screen. A description of the setting screen will be omitted. A stop button **1106** is used to stop imaging.

During Steps S**1001** and S**1002**, the shutter **183** shown in FIG. **2**B is in a state such as to block the measurement light. After start-up, the light quantity is constantly monitored by the light detector **184**, regardless of the step. When the light quantity exceeds a set value, it is determined that the quantity of light traveling toward the eye increases, and the shutter **183** is kept closed so that the measurement light does not travel toward the eye **107**. Moreover, an error message "LIGHT QUANTITY ERROR" is displayed.

In Step S**1003**, an imaging-position adjustment screen is displayed on the monitor, as shown in FIG. **4**B. Switching of the display is made when the examiner clicks an "ALIGNMENT" TAB shown in FIG. **4**A. An infrared-image screen **1201** of the eyeground is obtained by superimposing a tomographic-image pickup area **1202** on an image obtained by the infrared area sensor **321** shown in FIG. **2**A. More specifically, the infrared-image screen **1201** is shown as a figure indicating the scanning area displayed on the examination information screen shown in FIG. **4**A. A button **1204** is used to move the tomographic-image pickup area **1202** up, down, right or left. A tomographic-image pickup button **1203** is a signal input unit for an image pickup signal. A stop button **1206** is similar to the stop button **1106** described in the above description of Step S**1002**. In this Step S**1003**, the examiner aligns the eyeground imaging apparatus **200** with the eye **107**. More specifically, the examiner places working dots **1211** at symmetrical positions in the up-down direction and right-left direction and minimizes the size of the working dots **1211** by operating the joystick **805** while viewing the infrared-image screen **1201** or the monitor **391** provided in the eyeground-image pickup unit **300**. This allows the optical axis of the apparatus to coincide with the optical axis of the eyeground, and forms an appropriate distance between the eye **107** and the objective lens **302**. Focus onto the eyeground is adjusted by turning the knob (not shown) to move the lens **305** shown in FIG. **2**A so that two splits **1212** are aligned horizontally.

This alignment is similar to alignment adopted in the retinal camera of the related art. Step S**1003** corresponds to a waiting period for the next step to be performed by the examiner's entry from the tomographic-image pickup button **1203** on the screen or the control switch **804**. In this step, the program of the control unit **125** determines that a command to capture a tomographic image is input when the tomographic-image pickup button **1203** serving as the signal input unit of the imaging operation or the control switch **804** is pressed. To adjust a necessary portion of the retina to be imaged, a light-emitting point of the fixation lamp **320** is adjusted as an adjustment to be made on the side of the eye **107**, and the tomographic-image pickup area **1202** is adjusted by the button **1204** on the screen or a controller (not shown) provided in the eyeground-image pickup unit **300**.

In Step S**1004**, when the examiner clicks the tomographic-image pickup button **1203** on the screen or presses the control button **804**, the control unit **125** receives this input, and causes the XY scanner **408** to scan according to set information. Simultaneously, the control unit **125** opens the shutter **183** so as to apply the measurement light onto the eye **107**. In contrast, the quick-return mirror **318** in the eyeground-image pickup unit **300** remains down, and only the infrared light for tomographic imaging is guided to the dichroic mirror **405** for splitting, so that no light is guided to the camera unit **500**. Here, the control unit **125** reads interference signals at positions on the eyeground from the line sensor **182** by operating the XY scanner **408**. On the other hand, light having multiplexed wavelengths is incident on pixels of the line sensor **182**. Wavelengths obtained by subjecting intensity information about the wavelengths to Fourier conversion by the line sensor **182** serve as intensity information about return light at the positions of the eyeground in the depth direction. This is based on the general principle of a spectral domain OCT (SD-OCT). One-dimensional data on a certain point on the eyeground in the depth direction is referred to as A-scan data. In this step, scanning is performed until intensity information about each position is acquired. After the completion of scanning, the shutter **183** is closed and the Xi scanner **408** is stopped.

Step S**1004** automatically shifts to Step S**1005**, where a tomographic-image check screen is displayed, as shown in FIG. **5**A. A tomographic-image check display **1305** displays tomographic images in the x-direction, which are captured at a certain position in the y-direction (A-scan data are arranged in the x-direction, and referred to as B-scan images), together with the scanning number **1305**. Here, only about one-fifth of all B-scan images are displayed. By changing the setting, all B-scan images can be displayed, or conversely, only one-tenth of all B-scan images can be displayed. In this tomographic-image check display **1305**, small images are arranged in tiles so as to be checked easily. The displayed B-scan images for checking form tomographic images by thinning A-scan data in the x-direction. For example, while **1024** lines of A-scan data in the x-direction are captured according to the scan setting shown in FIG. **4**A, only **256** lines are displayed in this case. By subjecting only **256** lines of data to Fourier conversion and displaying the **256** lines side by side, one check tomographic image is obtained. While operation, such as fixed noise removal, is performed when observation tomographic images are formed in a later step for diagnosis, check images are obtained without performing the above-described operation in this case. This allows the check images to be more quickly displayed, and shortens the time taken for check and shift to the next step. In FIG. **5**A, an eyeground-image button **1301** is a signal input unit of the imaging operation. When there is no failure in tomographic imaging, a save button **1303** is clicked to store, in the storage unit **129**, the tomographic images, a plurality of pieces of intensity information obtained from the line sensor **182**. before the tomographic images are formed, or both of them. At the time of saving, not only a series of tomographic images are stored, but also the infrared-image screen **1201** used in Step S**1003** is stored. This allows the tomographic-image pickup area **1202** to be easily checked after imaging. A tomographic-image retake button **1304** serves as a selection input unit. To prevent an eyeground image from being captured without a saving operation, the eyeground-image pickup button **1301** may be displayed after the saving button **1303** is pressed. This step corresponds to a waiting period in which a click of the eyeground imaging button **1301** or the tomographic-image recapturing button **1304** or a press of the control switch **804** is waited for after the check tomographic image is displayed. In this step, the program of the control unit **125** determines that the press of the eyeground-image pickup button **1301** or the control switch **804** corresponds to input of a command to capture an eyeground image, unlike in Step S**1003**, The examiner checks whether or not tomographic imaging fails halfway because of a blink, involuntary eye movement, or other causes while viewing the tomographic-image check display **1305**. For example, when a blink occurs, some B-scan images become seriously darker than the other B-scan images. When involuntary eye movement is large, a portion of the retina to be observed is not included in some B-scan images. On the other hand, when images having a relatively large quantity of A-scan data to be acquired, that is, high-definition tomographic images are three-dimensionally obtained, as in this example, the imaging time increases. As described in Step S**1002**, a blink is highly likely to occur in the imaging time of about 17 seconds, as described in Step S**1002**. When the images have the above-described defects, the examiner determines that tomographic imaging fails. Here, while the examiner determines whether or not acquisition of tomographic images is successful, the control unit **125** may determine whether or not a dark image is included in obtained B-scan images, and a display may be automatically made to urge the examiner to perform check, for example, an image judged a failure may be surrounded with a red frame.

In Step S**1006**, when tomographic imaging is successful, the examiner checks the position of the eyeground with the monitor **128**. When necessary, the examiner readjusts the position, and then clicks the eyeground-image pickup button **1301** or presses the control button **804**, in this case, the control unit **125** shifts the step to the next Step S**1007**, When tomographic imaging fails and it is necessary to capture a tomographic image again, the tomographic-image retake button **1304** is clicked. At this time, the control unit **125** performs Step S**1004** again so as to retake a tomographic image.

In Step S**1007**, an eyeground image is captured. The stroboscopic tube **314** is caused to emit light, and simultaneously, the quick-return mirror **318** is flipped up. In this state, an eyeground image is captured with the camera unit **500**, and is stored in the storage unit **129**.

In Step S**1008**, imaging is finished.

By clicking an "IMAGING RESULT DISPLAY" tab on the screen after a series of image pickup operations are finished, a tomographic-image display screen shown in FIG. **5**B is displayed. Reference numeral **1401** denotes a B-scan image serving as one of the obtained tomographic images. By operating a slider **1403** for B-scan selection, a B-scan image **1401** at a desired position is displayed. Reference numeral **1402** denotes an obtained eyeground image, and a tomographic-image pickup area **1405** is also displayed. The eyeground image displayed here is obtained by eyeground imaging, but is different from the infrared image **1201** of the eyeground stored in Step S**1005**. An image-quality setting slider **1404** for setting the quality of the tomographic image display is used to adjust the brightness and contrast of the image. Broken lines are shown for explanation, and in actuality, are not displayed on the screen. A stop button **1406** is similar to the stop button on the above-described display screen. The tomographic image displayed here is different from the tomographic image displayed for check in Step S**1005**. Thinning of A-scan data is minimized within the display range, and fixed noise is removed by operation. This allows precise observation of the tomographic image.

As described above, the eyeground imaging apparatus of the first example displays a tomographic image for checking between pickup of a tomographic image and pickup of an eyeground image, and selects between transition to pickup of an eyeground image and retake of a tomographic image. In this case, even if the apparatus simultaneously performs pickup of an eyeground image and pickup of a tomographic image that needs a relatively long imaging time, a tomographic image can be retaken without waiting for recovery of the eye from contraction of the pupil due to a flare of flashlight. Moreover, since the control switch can be operated to capture a tomographic image or to capture an eyeground image in accordance with the state of the screen display, the apparatus can be simplified.

While tomographic imaging is performed by SD-OCT in the first example, it may he performed by time domain OCT (TD-OC) or swept-source OCT (SS-OCT).

Examples_Second Example: Preview of Tomographic Image

Next, an eyeground imaging apparatus according to a second example will be described. The second example is different from the first example in a part of a method for capturing a tomographic image and an eyeground image. Since the configuration of the apparatus, configuration of an optical system of the apparatus, and a configuration of a tomographic-image pickup unit are similar to those adopted in the first example, descriptions thereof are omitted, and a method for capturing a tomographic image and an eyeground image will be described.

Method for Capturing Tomographic Image and Eyeground Image **2**

An image capturing method using the eyeground imaging apparatus of the second example will be described with reference to FIGS. **4**C and **6**, The same structures of the apparatus as those of the first example are denoted by the same reference numerals, Steps in an imaging flowchart shown in FIG. **6** will be described in order.

In Step S**2001**, imaging is started. A control unit **125** executes an imaging program, and displays an imaging screen on a control-unit monitor **128**, in a manner similar to Step S**1001** of the first example.

In Step S**2002**, an examination information screen is displayed on the control-unit monitor **128**, in a manner similar to Step S**1002** of the first example.

In Step S**2003**, an imaging-position adjustment screen is displayed on the control-unit monitor **128**, as shown in FIG. **4**C. The display on the control-unit monitor **128** is switched by the examiner's click of an "ALIGNMENT" tab shown in FIG. **4**A. An infrared eyeground-image screen **2201** displays a tomographic-image pickup area **2208** superimposed on an image captured by an infrared area sensor **321** shown in FIG. **2**A. A button **2204** is used to move the tomographic-image pickup area **2208** up, down, right, and left. A tomographic-image pickup button **2203** is not displayed in Step S**2003**, but is displayed in the next Step S**2004**. A stop button **2206** is similar to the stop button adopted in the first example. In this step, the examiner aligns an imaging apparatus **200** and an eye **107** to be examined. Since alignment is performed in a manner similar to that adopted in the first example, a description thereof is omitted. FIG. **4**C also illustrates a preview screen **2202** for a tomographic image, a slider **2207** for indicating the gate position, and a signal-level indicator **2205**. These portions will be described in the following description of Step S**2004**. Broken lines are shown for explanation, but are not displayed on an actual screen. In this Step S**2003**, the imaging program determines that a signal for capturing a tomographic image for a preview (Step S**2004**) is input when a control switch **804** serving as an input unit for imaging is pressed. Further, a light-emitting position of a fixation lamp **320** is adjusted as adjustment made on the side of the eye **107** to adjust a necessary imaging portion of the retina, and the position of the tomographic-image pickup area **2208** is adjusted with the button **2204** on the screen or a controller (not shown) provided in a main unit **300**. The adjustment of the light-emitting position of the fixation lamp **320** and the adjustment of the tomographic-image pickup area **2208** can be made in this step and the next Step S**2004**.

In Step S**2004**, when the examiner presses the control switch **804**, an XY scanner **408** starts, and simultaneously, a shutter **183** opens to apply measurement light onto the eye **107**, so that preview scanning starts to adjust tomographic imaging. Simultaneously, the tomographic-image pickup button **2203** serving as the signal input unit for imaging is displayed on the screen. This preview scanning is performed near a center line **2208***a* of the tomographic-image pickup area **2208** in the horizontal direction in FIG. **4**C, and an obtained B-scan image is displayed on the tomographic-image preview screen **2202**. During preview scanning, B-scan images are recaptured at the same position in the y-direction, and are displayed sequentially. The examiner makes adjustments for tomographic imaging while viewing the tomographic-image preview screen **2202**. First, gate position adjustment is made with a stage controller (not shown). Gate position adjustment refers to adjustment for the difference in optical path length from reference light by moving an electric stage (**117** in FIG. **2**B) to which a mirror **114** in FIG. **2**B for folding the reference light. That is, gate position adjustment is adjustment for a cross-sectional position of the retina in the vertical direction of the screen. Particularly in tomographic imaging, the brightness becomes the highest at a position where the optical path lengths of the reference light and the object to be measured coincide with each other (this position is referred to as a gate position). Hence, it is necessary that the cross-sectional position of the retina should be located near a position where the optical path length thereof coincides with the optical path length of the reference light. However, if the gate position is set in the cross section of the retina, a mirror image due to Fourier conversion appears on the screen on the principle of SD-OCT. Hence, in order to obtain the best image, the retina position is set to be near the gate position, but not to be in the cross section of the retina. While the examiner adjusts the gate position in this example, the control unit **125** may automatically adjust the gate position on the basis of, for example, the brightness in the screen. The slider **2207** for indicating the gate position indicates where the gate position is located on the examiner side or the subject side, and functions as a guide for movement of the electric stage **117**. Further, the signal-level indicator **2205** indicates the ratio of the maximum brightness of the preview B-scan image and the brightness of background noise. As the position of a mark in the signal-level indicator **2205** moves to the right, the brightness of the image increases. With reference to this indicator **2205**, the examiner adjusts the focus or finely adjusts the position of the main unit **300** with the joystick **805**. This step corresponds to a waiting period for the next step of tomographic imaging to be performed when the examiner makes input from the tomographic-image pickup button **2203** on the screen or the control switch **804**. In this step, the program of the control unit **125** determines that a signal for tomographic imaging is input when the tomographic-image pickup button **2203** serving as the input unit for the imaging signal or the control switch **804** is pressed, in a manner similar to Step S**1003** of the first example. Moreover, in a manner similar to Step S**1003** of the first example, the light-emitting position of the fixation lamp **320** is adjusted as adjustment to be made on the side of the eye **107** in order to adjust the necessary imaging position of the retina, and the tomographic-image pickup area **2208** is adjusted with the button **2204** on the screen or the controller (not shown) provided in the main unit **300**.

In Step S**2005**, when the examiner clicks the tomographic-image pickup button **2203** on the screen or presses the control switch **804**, the control unit **125** receives this input, and tomographic images are captured, in a manner similar to that adopted in the first example.

Step S**2005** automatically shifts to Step S**2006**, In Step S**2006**, a tomographic-image check screen is displayed, in a manner similar to that adopted in the first example. In this step, after a tomographic image for check is displayed, a click of an eyeground-image pickup button **1301** or a tomographic-image retake button **1304** on the screen or a press of the control switch **804** is waited for. In this step, the program of the control unit **125** determines that a signal for capturing an eyeground image is input when the eyeground-image pickup button **1301** serving as the input unit for the image pickup signal or the control switch **804** is pressed, in a manner similar to that adopted in the first example.

In Step S**2007**, the examiner views the tomographic-image check display, and checks whether or not tomographic imaging fails halfway because of a blink, involuntary eye movement, or other causes. When tomographic imaging is successful, the examiner checks position adjustment with respect to the eyeground on the monitor **128**. If readjustment is necessary, it is made, and then, the eyeground-image pickup button **1301** is clicked or the control switch **804** is pressed.

When tomographic imaging fails and it is necessary to retake a tomographic image, the process can be returned to Step S**2003** by clicking the "ALIGNMENT" tab serving as the selection input portion in this step. This allows the gate, focus, and position of the main unit to be more finely adjusted in retaking of the tomographic image.

In Step S**2008**, an eyeground image is captured in a manner similar to that adopted an the first example.

In Step S**2009**, imaging is finished.

By clicking an "IMAGING RESULT DISPLAY" to on the screen after imaging is finished, a tomographic-image display screen is displayed, in a manner similar to that adopted in the first example.

If the stop button **2204** is clicked during preview display in Step S**2004**, or when the screen is changed to another screen by a click of a tab different from the "ALIGNMENT" tab, the shutter **183** is closed to block the measurement light so that the measurement light does not travel toward the subject side. When the "ALIGNMENT" tab is clicked again, the state in Step S**2003** is brought about.

As described above, the eyeground imaging apparatus of the second example performs a preview of a tomographic image in imaging adjustment (Step S**2003**), in addition to the operations performed in the first example. Therewith, the state of the apparatus can be adjusted to improve the quality of a captured tomographic image, for example, when only one B-scan tomographic image is captured. Further, since the process can be returned to the step of imaging adjustment (Step S**2003**) at the time of retake of a tomographic image, the gate, focus, and position of the main unit can be adjusted more finely. In addition, preview scanning can be started with the control switch, and this simplifies the apparatus and reduces the operation load on the examiner.

Examples_Third Example: Adaptor

Next, an eyeground imaging apparatus according to a third example will be described.

The third example is different from the first example in a part of a configuration of the apparatus. In the following, structures similar to those adopted in the first example denoted the same reference numerals, and descriptions thereof are omitted.

An overall configuration of the eyeground imaging apparatus of the third example will be described with reference to FIGS. **1**B and **1**C. FIG. **1**B is a side view of an eyeground imaging apparatus **200** of the third example. The imaging apparatus **200** includes a tomographic-image pickup unit **100**, a retinal-camera main unit **900**, an adaptor **400**, and a camera unit **500**. The retinal-camera main unit **900**, the adaptor unit **400**, and the camera unit **500** are connected optically. The retinal-camera main unit **900** and the adaptor **400** are held to be movable relative to each other so that rough optical adjustment is possible. Further, the adaptor unit **400** and the tomographic-image pickup unit **100** are optically connected by an optical fiber **148**. The adaptor **400** and the tomographic-image pickup unit **100** have a connector **410** and a connector **147**, respectively, and therefore, can be attached and detached easily. The eyeground imaging apparatus **200** also includes a personal computer **925** for forming a tomographic image and a control-circuit unit **905**. The personal computer **925** and the control-circuit unit **905** are similar to the control unit adopted in the first example. A personal-computer monitor **928** and a storage unit **929**, such as a hard disk, may be incorporated in the personal computer **925**.

Alternatively, as shown in Fig. IC, the retinal-camera main unit **900** and the camera unit **500** can constitute one retinal camera **700**. Since the tomographic-image pickup unit **100** is not used in this case, the control circuit unit **905** is also unnecessary. The retinal camera **700** can be changed to the eyeground imaging apparatus by detaching the camera unit **500** from the retinal-camera main unit **900** and attaching the adaptor **400** between the camera unit **500** and the retinal-camera main unit **900**.

Configurations of Optical Systems of Retinal Camera, Adaptor, and Camera Unit

The configuration of the optical system of the eyeground imaging apparatus of the third example including the adaptor will be described with reference to FIG. **7**A. The same components as those adopted in the first example are denoted by the same reference numerals. In the third example, the main unit of the first example of the first example is divided into the retinal camera unit **900** and the adaptor **400**. The adaptor **400** includes a dichroic minor **405**, relay lenses **406** and **407**, a collimator lens **409**, an XY scanner **408**, and the connector **410**. An optical system on the eye side including an optical path **351** is entirely included in the retinal-camera unit **900**. Since details of the structures are similar to those adopted in the first example, descriptions thereof are omitted, In the retinal camera **700** shown in FIG. **1**C, the relay lens **308** in the retinal-camera unit **900** serves to form an eyeground image on an area sensor **501** provided in the camera unit **500**.

Structure of Tomographic-Image Pickup Unit

Since the structure of the tomographic-image pickup unit **100** is similar to that adopted in the first example, a description thereof is omitted. However, a portion connected to the control unit **125** in the first example is connected to the control-circuit unit **905** in the third example.

Method for Capturing Tomographic Image and Eyeground Image 3

First, a method tor capturing an eyeground image with the retinal camera **700** shown in FIG. **1**C will be described with reference to a flowchart of FIG. **7**B.

In Step S**3001**, imaging starts, a program only for the retinal camera **700** is started on the monitor **928** by the personal computer **925**, and an imaging screen is displayed, in a manner similar to Step S**1001** of the first example.

In Step S**3002**, an examination information screen is displayed. While this step is substantially equivalent to Step S**3002** of the first example, scanning is not performed in the third example. Hence, information about scanning is not displayed.

In Step S**3003**, an eyeground in-plane alignment screen is displayed. When the retinal camera is used, an infrared eyeground image for position adjustment is displayed on a monitor **901**, and the examiner adjusts the position of the retinal-camera main unit **900** with a joystick **903** and adjusts the focus with a knob (not shown) on the basis of the displayed infrared eyeground image. In this step, the program only for the retinal camera **700** determines to capture an eyeground image when a signal for imaging is input from a control switch **904** serving as an input unit for the imaging signal. In response to the signal, the process proceeds to Step S**3004**.

In Step S**3004**, an eyeground image is captured, in a manner similar to Step S**100**; of the first example. Data on the captured eyeground image is displayed on the monitor **928** via the retinal-camera main unit **900**, and is stored in the storage unit **929**.

In Step S**3005**, imaging is finished.

A method for capturing a tomographic image and an eyeground image with the imaging apparatus **200** is similar to that adopted in the first and second examples, and therefore, a description thereof is omitted.

When the retinal camera **700** is changed to the eyeground imaging apparatus **200**, the tomographic-image pickup unit **100**, the adaptor **400**, the camera unit **500**, and the retinal-camera main unit **900** are connected to the personal computer **925** via the control-circuit unit **905**. A light source, a shutter, a line sensor, and an XY scanner, which are controlled objects specific to tomographic imaging, have a driver and so on in the control-circuit unit **905**, and can be controlled with the personal computer **925** by connecting the control-circuit unit **905** between the adaptor **400** and the personal computer **925**. Further, the control switch **904** provided in the retinal-camera main unit **900** and the camera unit **500** are also connected to the control-circuit unit **905**, and can thereby be controlled as the eyeground imaging apparatus **200**, unlike the retinal camera **700**. This can respond to different functions of the signal input unit **904** corresponding to the steps in a manner similar to that adopted in the first and second examples. For example, while preview scanning is started when the control switch **904** is pressed in Step S**2004** of FIG. **6**, control specific to the eyeground imaging apparatus **200** can be performed in this case, for example, pickup of an eyeground image with the camera unit **500** is not performed even when the control switch **904** is pressed.

Accordingly, in the third example, the retinal camera can be easily changed to the eyeground imaging apparatus capable of capturing a tomographic image. Moreover, the control switch is commonly used in the retinal camera and the eyeground imaging apparatus. This reduces the number of components, and allows both the retinal camera and the eyeground imaging apparatus to be used without substantially changing usability of the examiner and without giving any feeling of discomfort to the examiner.

Other Embodiments

Aspects of the present invention can also be realized by a computer of a system or apparatus (or devices such as a CPU or MPU) that reads out and executes a program recorded on a memory device to perform the functions of the above-described embodiment(s), and by a method, the steps of which are performed by a computer of a system or apparatus by, for example, reading out and executing a program recorded on a memory device to perform the functions of the above-described embodiment(s). For this purpose, the program is provided to the computer for example via a network or from a recording medium of various types serving as the memory device (e.g., computer-readable medium).

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2009-151485, filed Jun. 25, 2009, which is hereby incorporated by reference herein in its entirety.

The invention claimed is:

**1**. An apparatus comprising:

an eyeground-image pickup unit configured to take a two-dimensional image of an eyeground of a subject;

a tomographic-image pickup unit configured to take a tomographic image of the eyeground, the tomographic-image pickup unit including an optical system which is used in common with the eyeground-image pickup unit;

an output unit configured to output a signal relating to the tomographic image so as to display the tomographic image by a display unit;

a control unit configured to control the eyeground-image pickup unit, the tomographic-image pickup unit, and the output unit;

a signal input unit configured to input a signal relating to the control of the control unit; and

a selection input unit configured to select a retake of a tomographic image by inputting a signal,

wherein the control unit controls, in response to the signal input from the signal input unit, the tomographic-image pickup unit so as to take the tomographic image, controls the output unit so as to output the signal relating to the tomographic image to the display unit, and controls, in a case where the signal relating to the tomographic image is output from the output unit, the eyeground-image pickup unit so as to take the two-dimensional image in response to the signal input from the signal input unit and the tomographic-image pickup unit so as to retake the tomographic image in response to the signal input from the selection input unit.

**2**. The apparatus according to claim **1**, wherein the control unit causes the output unit to output a signal relating to screen information to the display unit based on the signal input from the signal input unit or the selection input unit.

**3**. The apparatus according to claim **2**,

wherein the screen information includes an adjustment screen for adjusting an image pickup mode in which the two-dimensional image or the tomographic image is taken, and wherein the control unit controls the eyeground-image pickup unit or the tomographic-image pickup unit based on a signal relating to the image pickup mode adjusted on the adjustment screen.

**4**. The apparatus according to claim **1**,

wherein the eyeground-image pickup unit includes a main unit and a camera unit to which a camera is removably attached, and

wherein the apparatus further comprises:

an adaptor unit removably provided between the main unit and the camera unit, the adaptor unit splitting an optical path toward the camera unit and the tomographic-image pickup unit; and

a control circuit unit configured to input the signal input from the signal input unit to the adaptor unit and the main unit.

**5**. The apparatus according to claim **1**, further comprising:

an illumination unit configured to emit measurement light for taking the tomographic image; and

a light blocking unit configured to block the measurement light based on the signal input from the signal input unit.

**6**. The apparatus according to claim **1**, wherein the two-dimensional image is acquired by taking an image of the eyeground with visible light.

**7**. The apparatus according to claim **2**, wherein the control unit is configured to control either the tomographic-image pickup unit or the eyeground-image pickup unit so as to take an image based on a type of the screen information output from the output unit.

**8**. The apparatus according to claim **2**, further comprising:

a display control unit configured to cause the display unit to display a display form for selecting the taken tomographic image and the retake of the tomographic image of the eyeground

wherein the control unit is configured to control the eyeground-image pickup unit so as to take the two-dimensional image by the signal input from the signal input unit, after the taken tomographic image is displayed by the display unit.

**9**. The apparatus according to claim **8**, wherein the display control unit is configured to cause the display unit to display a display form for selecting storing of the taken tomographic image.

**10**. The apparatus according to claim **8**, wherein the display control unit is configured to cause the display unit to display the taken tomographic image and the display form, which is for selecting storing of the taken tomographic image, side by side in a same screen of the display unit.

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